# Trade in Value Added and Global Footprint: A Unified Output Accounting Framework

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## 1. Introduction

The development of international production networks and the construction of global multi-regional input-output (GMRIO) tables produced two areas of study. The literature on trade in value added has concerned the divergence between traditional trade statistics and value-added accounts. The global footprint literature has shown an increased interest in the impact of trade on environmental issues. Although there appears to be a relation between trade in value added and global footprint, very little discussion tried to link them.

One reason for the disconnection lies in the property of the total value-added multiplier (global Leontief inverse evaluated by direct value-added coefficients) of which all elements are unity. This convenient trait cannot be relied upon for attributes other than value added, such as $CO_2$ emissions, employment, land use, and biodiversity. This study proposes a new framework, not using the special property of the total value-added multiplier, and discusses all the relations in terms of output. We express the breakdown of gross exports by global matrices, simplifying the formula. Based on the new framework, we decompose global footprint measurements according to final destinations and the complexity of trade.

## 2. Methodology

Based on the GMRIO tables with G countries and N sectors, and basic relations in the input-output model, we propose a decomposition of $X$ with respect to trade complexity:

$$X = BY = LY^D + LY^F + LA^F LY^D + LA^F LY^F + LA^F LA^F BY,$$

where $B$ is the $GN \times GN$ global Leontief inverse matrix and $L$ is the local Leontief inverse matrix. $Y$ is the $GN \times G$ final demand matrix. $Y^D$ denotes final goods for domestic consumption, while $Y^F$ is final product exports. The element of $X$, for example, $x^{rs} = \sum_g B^{rg} y^{gs}$ represents a portion of country $r$'s output that is finally absorbed by country $s$. $A$ is the input coefficient matrix, where $A^D$ represents the domestic input coefficients and $A^F$ is the off-diagonal block matrix.

The breakdown of the global carbon emissions induced by the bilateral exports

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from country $s$ to country $r$ ($e^{sr}$) is:

$$fB^s e^{sr} = f^s L^{ss} e^{sr} + f^s \sum_{t \neq s} B^{st} A^{ts} L^{ss} e^{sr} + \sum_{t \neq s} f^t L^{tt} A^{ts} L^{ss} e^{sr} + \sum_{t \neq s} \sum_{g \neq t} f^t B^{tg} A^{gt} L^{tt} A^{ts} L^{ss} e^{sr} + \sum_{t \neq s} \sum_{g \neq t,s} f^t B^{tg} A^{gs} L^{ss} e^{sr}.$$

Here $f = [f^1 f^2 \cdots f^G]$ is the carbon emission coefficient vector. Superscripts indicate countries.

## 3. Main Results

By utilizing the OECD ICIO tables (2021 editions) and the $CO_2$ emissions coefficients from the TECO2 database, we provide some comparisons that illustrate the numerical difference between our accounting framework and previous methods. In contrast to Meng et al. (2018), which merely applied Wang et al. (2013)'s value-added decomposition method to carbon emissions, we construct the breakdown based on the output accounting and define domestic and foreign emissions more accurately. We also show the decomposition results of a country's consumption-based output according to trade complexity. Despite the proliferation of GVCs, on average, 77% of the final demand is met by pure domestic production, conversely, 10% is from traditional trade and 13% from GVC trade.

Table 1 Decomposition of global carbon emissions induced by Chinese bilateral exports for 2018

| | | liu and oka | | Meng et al. (2018) | |
|---|---|---|---|---|---|
| Bilateral Relationship | Gross exports (million USD) | Domestic emissions (kt) | Foreign emissions (kt) | Domestic emissions (kt) | Foreign emissions (kt) |
| CHN_EU15 | 352515 | 231874 | 19751 | 232521 | 18696 |
| CHN_EU13 | 54627 | 37045 | 3281 | 37134 | 2586 |
| CHN_JPN | 190972 | 128049 | 10883 | 128062 | 11531 |
| CHN_USA | 490471 | 311210 | 28281 | 312890 | 35528 |

## 4. Conclusion

In this paper, by freeing from the property of the total value-added multiplier, we proposed a general scheme for trade in value added and global footprint. This accounting framework is expressed in terms of output, to which any attribute is included by multiplying their coefficients. Additionally, we find that despite the criticism towards the world perspective in trade in value added studies, it remains crucial for addressing global issues such as climate change.

## Reference

Meng B, Peters G P, Wang Z, et al. Tracing CO2 emissions in global value chains[J]. Energy Economics, 2018, 73: 24-42.

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